still more anxiously when I learnt that something of the kind was seriously suspected by Dr. Larmor.

Applying a field of 1400 C.G.S. units over a length of light path of about 14 metres in the aggregate, things were so arranged that a drift of 1 foot a second, or about 10^{-9}th of the velocity of light, would have been observed by a fractional shift of micrometrically viewed interference bands, if it had occurred. But no effect whatever on the interference bands could be detected, nor was anything observed when—with less perfect vision, in that case, owing to increased difficulties—the air along the field and path of light was replaced by bisulphide of carbon; except that, of course, if plane-polarised light was used, the plane was then rotated by a very large amount. Sufficient details of this series of negative experiments will be given in the forthcoming April issue of the *Philosophical Magazine*.

The result was to show that if the magnetic energy were to be accounted for in the assumed kinetic fashion, the density of the ether must be very considerable—in fact about 180 times that of water—in order to give the actual energy with a velocity below what could be observed in this way.

I have now, however, as described above, made a theoretical estimate of the density of the ether—arriving at the tentative conclusion that it is of the order 10^{12}—and we can therefore proceed to calculate what velocity of hypothetical ethereal drift is to be expected in any given magnetic field. It will come out, of course, exceedingly slow; for, on this view, the electromagnetic unit of field is $\mu^{-\frac{1}{2}}$, which equals 3×10^{-6} centimetre per second, and the velocity to be expected is the 2πth of that.

So, for instance, the field inside a solenoid, surrounded by a current of 100 amperes circulating 100 times round every centimetre of it, being $4\pi n_1 C$, will equal 12,000 C.G.S.; which corresponds with a velocity of 0·003 centimetre per second, or about 4 inches an hour. In fact, the ampere turns per inch, in any solenoid, measures the speed of magnetic circulation along its axis, no matter what the material of the core may be, in millimicrons per second.

When iron is substituted for air, the speed is the same; but the ethereal density is virtually increased, by the loading due to the molecular whirls in the iron.

It may seem difficult to reconcile this very slow velocity, in any ordinary field, with the great velocity, of the very same character, already postulated in the immediate neighbourhood of an electron; where it is supposed that the magnetic circulation is equal to, or at any rate of the same order of magnitude as, the locomotion speed—which it is well known may easily be 1/30th of the velocity of light, without departing appreciably from the simply calculated inertia. But that great speed, in the immediate neighbourhood of an electron, can be fully admitted; and there is nothing really inconsistent in that with the slow speed observed at any ordinary distance. For instance, if, close to the equator of a flying electron, the ethereal magnetic speed is 1/30th of the velocity of light, or 10^9 centimetres per second; then, at a distance of 1 millimetre away, the speed is reduced to 10^{-24}th of that value, and is, therefore, even at that small distance, only 10^{-15} centimetre per second, or 3 millimicrons per thousand years.

The speed at the axis of a solenoid is, of course, far greater than that, because of the immense number of electrons in any ordinary current surrounding it; but, in order to get up a drift-velocity of 1 centimetre per second in a solenoid, a thousand amperes would have to circulate three thousand times round every centimetre of it; which seems hardly practicable.

The optical arrangements, in my experiment above spoken of, could doubtless be improved sufficiently to show an ether drift of 1 centimetre per second; but I do not see how to produce a field of the required intensity to give even this leisurely flow. Such a field would have to be about four million C.G.S. units, and must exist throughout a great length of air.

The experimental verification of the above theoretical estimate of ethereal density seems therefore to be beyond the reach of this form of experiment. Nevertheless, I feel reasonably convinced that there is a justification for assuming the ether to have properties such as can only for the present be represented, in analogy with the properties of matter, by saying that its behaviour consistently indicates something typified by its possession of an immense elasticity or rigidity, 10^{33} dynes per square centimetre, caused by its intrinsic constitutional energy; combined with a property analogous to, and resulting in, material inertia, and typified by attributing to it a density of the order 10^{12} grams per cubic centimetre. The ethereal property, here called elasticity, is certainly the source and origin of every kind of material elasticity and potential energy; for the only real static effect producible in the particles of matter is a change in their arrangement or configuration. All stress must exist really in the ether.

Although the experimental methods so far suggested have proved themselves unable to test the magnitudes involved in these high values, some other method of inquiry may be suggested, and the theory may yet be brought to the test of experiment. OLIVER LODGE.

THE INSTITUTION OF NAVAL ARCHITECTS.

THE annual spring meeting of the Institution of Naval Architects was held last week at the Society of Arts, commencing Wednesday, March 20, and being continued over the two following days. Fourteen papers were read and discussed, some of them at considerable length, while Lord Glasgow's presidential address, the report of the council, and other necessary business received due attention.

The first paper taken was a contribution by Mr. James McKechnie, of Barrow, the subject being the influence of machinery on the gun-power of the modern warship. This paper was full of information, but perhaps the most interesting part was that in which the author compared the elements of design of three imaginary battleships, propelled respectively by steam, gas, or oil engines. It is somewhat startling to find the chief engineer of one of our most powerful shipbuilding and engineering companies—and one, too, so largely engaged in the production of war material—should think gas or oil engines, as propulsive agents for the largest warships, sufficiently within the possibilities of the near future as to make it the subject of a paper before this important institution; it is prophetic of still vaster changes in store than even the transition from shell boilers to water-tube boilers, and from reciprocating engines to the steam turbine. Mr. McKechnie, however, intimated during the discussion on his paper that his company, Vickers, Sons and Maxim, was quite prepared to build a warship with gas-producers in place of boilers, and gas engines in place of steam engines, if any Government had the courage to give them an order. It would seem almost that steam's unconquerable arm is likely to have its supremacy challenged even in that field where we have hitherto held it to be most secure.

Mr. McKechnie takes for his comparison the designs of three battleships, each of 16,000 horse-power. The one propelled by steam would have machinery that would develop 10·1 horse-power per ton weight of machinery; the gas-driven machinery would give 14·48 horse-power per ton, whilst the oil engines and machinery would give off 21·33 horse-power per ton. Probably an oil-engined battleship may be considered outside the bounds of practical engineering application until oil fuel becomes far more plentiful than there appears to be any prospect of it being at present, waiting, of course, that gloomy but undefined era when the coal supplies of the world are exhausted. If, however, we confine ourselves to coal fuel, it is certainly a tempting offer which the engineer offers to the naval architect, this increase of nearly 50 per cent. in the power developed on a given weight. There are, however, other inducements. With the steam engine the area occupied by machinery per unit of power is 0·453 square foot, whilst of the gas engine but 0·336 square foot is needed for each horse-power developed. That also is a very substantial gain in a battleship, where every inch of space is so costly to produce and so urgently needed.

The third chief consideration Mr. McKechnie brings forward is fuel economy. Steaming at full power, the coal

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burnt would be 1·6 lb. per indicated horse-power with one ship, whilst the sister vessel would be "gassing" (we shall have to become reconciled to the objectionable term) with a consumption of 1 lb. of coal per indicated horse-power per hour. Here is a saving of more than 50 per cent. in weight of coal carried, bunker space, time of coaling, and other subsidiary matters, amongst them money cost. At lower powers the figures bear approximately the same ratio.

These are enormous strategical advantages, but the tactical benefits offered are hardly less pronounced. By means of profile views the author showed the gun emplacements of the two ships. With the usual two-chimney arrangement of the steam ship, there are four 12-inch guns placed in pairs in two barbettes at the ends of the battery, as is usual. These have arcs of training, a few degrees before or abaft the beam respectively, whilst the weapons of a lighter nature can only fire on their respective broadsides. When we turn to the ship without boilers—the gas-engine ship—we find the space that would be taken in the other vessel by funnels, uptakes, &c., occupied by three additional barbettes placed *en echelon*, and each containing two 12-inch guns. There are also the two end barbettes with their four guns, as in the steam ship. These six centrally placed guns can be, moreover, trained on either broadside, so that, in an encounter between the steam ship and the gas ship the latter could bring ten 12-inch guns into action as against four of the former vessel, supposing the encounter to be broadside on; or, to put the case another way, the gas ship could fight a steam ship on each broadside, and have a superiority over her enemies of two 12-inch guns. With secondary armament the problem is more complicated, and could hardly be explained without diagrams.

What, it will be asked, are the defects of these qualities? and an answer can only be given by the light of experience—an experience only likely to be gathered by steps. The marine steam engine has been brought to such a state of efficiency that its performance can be practically depended upon; this is not the case with the producer gas engine. There are many things to find out yet, the problem being more complex from the combination of mechanical and chemical sciences that have to be applied. With gas engines afloat—a very different thing from gas engines ashore supplied from a central source—one hears of the explosive mixture failing, from unexplained causes, and the engines stopping without warning, and there are details of working connected with ignition and other points which have yet to be perfected. For much the same reason that many naval engineers prefer hydraulics to electricity for working armaments, steam is likely to be preferred to gas for propelling battleships. Which will ultimately survive time will show; in the meantime, it may be said Mr. McKechnie has worked out a very strong case for gas.

The remaining paper taken on this day was by Mr. Simon Lake, who dealt with the subject of submarine boats. The type of vessel the author advocates is fairly well known, its most striking characteristic being that it is fitted with wheels so that it can travel along the bottom of the sea. The paper gave an interesting account of some of Mr. Lake's adventures in his ingeniously devised craft.

On the second day of the meeting Mr. W. J. Luke, of Clydebank, read a paper in which details of certain points in the construction of the new big Cunard ship *Lusitania* were set forth. The chief point was the application of high tensile steel in the upper part of the hull structure, a detail of shipbuilding design which possesses definite advantages, seeing that the hogging stresses are more serious than the sagging stresses, and therefore tension is of high importance for the upper member of the girder formed by the hull structure. The evolution of the modern cargo steamer was the subject of a paper by Mr. S. J. P. Thearle, of Lloyd's. It was a contribution that will be of value in the Transactions of the institution for future students of the history of shipbuilding. Cranes for shipbuilding afforded a subject of practical interest for Signor C. Piaggo.

The two papers that were read at the evening meeting of the same day were both of interest and importance. They described two forms of instrument for measuring the power given off by turbines. The author of the first paper was Mr. A. Denny, and of the second Mr. J. H. Gibson. As is well known, the ordinary steam-engine indicator, by which horse-power has been measured since the days of James Watt, is useless for application to turbines, because there is no reciprocating motion with the latter. This has been a serious obstacle in the path of ship designers, but it appears to have been overcome by taking indicators of the torsion of the shafting through which power is conveyed from the turbine to the propeller. In both the instruments described by the authors of the two papers recourse is had to this means, but the method of recording is different. In the Denny and Johnstone torsiometer is an electrical method in which a telephone is used, whilst in Mr. Gibson's instrument recourse is had to a flash of light deflected by a mirror. The details by which these processes are made practical have been worked out in each case with great ingenuity, but it would be difficult to make them clear without illustrations. It may be pointed out, as Lord Glasgow stated at the meeting, that the successful application of these instruments will solve a problem that the elder Froude worked out with much enthusiasm during the later years of his life, though with very partial success. A paper on propeller struts, by Mr. G. Simpson, was of purely professional interest.

One of the most interesting papers of the meeting was Sir William White's contribution on experiments with Dr. Schlick's gyroscopic steadying apparatus. This paper is of such interest that we propose to deal with it separately. Its full comprehension, however, involves a knowledge of the principles set forth in a paper read by Dr. Schlick a few years ago, Sir William having thought it unnecessary to go over the same ground again.

The other papers read were on the approximate formulæ for determining the resistance of ships, by A. W. Johns; on the application of the integraph to ship calculations, by J. G. Johnstone; on the prevention of fire at sea, by Prof. Vivian B. Lewes; on modern floating docks, by Lyonel Clark; and on some phases of the fuel question, by Prof. Vivian B. Lewes.

The institution will hold a summer meeting in Bordeaux towards the end of June.

TICKS AS TRANSMITTERS OF DISEASE.[1]

MANY statements are found in medical works as to the local poisonous effects of tick bites, but these are of small importance compared with the diseases inoculated by ticks. Until a year or so ago ticks were only known to transmit one kind of disease, and this was confined to the lower animals. Of these diseases, "Texas" fever in cattle may be regarded as the type. These diseases, which are met with in cattle, horses, asses, sheep, and dogs, are due to parasites which attack the red cells of the blood. The parasites are characterised by their pear shape, and hence were originally called Pyrosoma; but this name has now generally been replaced by Piroplasma, and the infection by these parasites is known as piroplasmosis.

Smith and Kilborne in America, by their classical researches, first established the fact that Texas fever in cattle was transmitted by ticks. We may consider the mode of transmission somewhat more closely. Ticks in their life-history go through the stages of eggs, larva, nymph, and adult. In the case of transmission of malaria by certain Anophelines, we know that the adult mosquito when it has fed on the blood of a malarial patient can transmit the disease again after the lapse of ten days, more or less, to a healthy person. Very different, however, is the mode of transmission of piroplasmosis by ticks. Smith and Kilborne showed that Texas fever was transmitted from the sick to the healthy animal, not by adult ticks, but that it was young ticks hatched from the eggs

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[1] "Scientific Memoirs by Officers of the Medical and Sanitary Departments of the Government of India." New series, No. 23.

"The Anatomy and Histology of Ticks." By Capt. S. R. Christophers. Pp. 55+plates. (Calcutta: Office of the Superintendent of Government Printing, 1906.) Price 4*s*. 6*d*.

Memoir xxi. of the Liverpool School of Tropical Medicine, September, 1906. Pp. xiv+118+plates. (London: Williams and Norgate.) Price 7*s*. 6*d*. net.

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